Prof Dr Sadebeck
With Regards of
H. J. Webber

BULLETIN No. 8.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY

THE PRINCIPAL DISEASES

OF

CITROUS FRUITS IN FLORIDA.

BY

WALTER T. SWINGLE

AND

HERBERT J. WEBBER.

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DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY.

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PUBLICATIONS OF THE DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY.

The Division of Vegetable Physiology and Pathology, formerly a section of the Division of Botany, became a separate organization by act of Congress approved July 14, 1890. Since that date its bulletins have been numbered independently and in a separate series, but the following list includes the publications of the Division under its former as well as under its present organization. Nos. 1, 3, 4, and 6, omitted from the series of bulletins published by the Section of Vegetable Pathology, are publications of the Division of Botany not relating to vegetable pathology. Only those documents marked with an asterisk are still on hand for distribution.

SECTION OF VEGETABLE PATHOLOGY, DIVISION OF BOTANY.

Journal of Mycology:

Vol. V, Nos. 1, 2, 3, 4. Pp. 249, pls. 14. 1889–'90.
Vol. VI, No. 1. Pp. 44, pls. 2. 1891.

Bulletins:

No. 2. Fungous Diseases of the Grapevine. Pp. 136, pls. 7. 1886.
No. 5. Report on the Experiments made in 1887 in the Treatment of Downy Mildew and Black Rot of the Grape. Pp. 113. 1888.
No. 7. Black Rot. Pp. 29, pl. 1. 1888.
No. 8. A Record of some of the Work of the Division. Pp. 69. 1889.
No. 9. Peach Yellows: A Preliminary Report. Pp. 254, pls. 36, maps and diagrams 9. 1888.
No. 10. Report on the Experiments made in 1888 in the Treatment of Downy Mildew and Black Rot of the Grape. Pp. 61, pls. 2. 1889.
No. 11. Report on the Experiments made in 1889 in the Treatment of Fungous Diseases of Plants. Pp. 119, pls. 8. 1890.

Circulars:

No. 1. Treatment of Downy Mildew and Black Rot of the Grape. Pp. 3. 1885.
No. 2. Grapevine Mildew and Black Rot. Pp. 3. 1885.
No. 3. Treatment of Grape Rot and Mildew. Pp. 2. 1886.
No. 4. Treatment of the Potato and Tomato for Blight and Rot. Pp. 3. 1886.
No. 5. Fungicides or Remedies for Plant Diseases. Pp. 10. 1888.
No. 6. Treatment of Black Rot of the Grape. Pp. 3. 1888.
No. 7. Grapevine Diseases. Pp. 4. 1889.
No. 8. Experiments in the Treatment of Pear Leaf Blight and Apple Powdery Mildew. Pp. 11. 1889.
No. 9. Root Rot of Cotton. Pp. 4. 1889.

DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY.

Journal of Mycology:

Vol. VI, Nos. 2, 3, 4. Pp. 163, pls. 16. 1890–'91.
Vol. VII, Nos. 1,* 2, 3,* 4.* Pp. 475, pls. 36. 1891–'94.

Bulletins:

No. 1.* Additional Evidence on the Communicability of Peach Yellows and Peach Rosette. Pp. 76, pls. 39. 1891.
No. 2.* The California Vine Disease. Pp. 222, pls. 27. 1892.
No. 3. Report on the Experiments made in 1891 in the Treatment of Plant Diseases. Pp. 76, pls. 8. 1892.
No. 4. Experiments with Fertilizers for the Prevention and Cure of Peach Yellows, 1889–'92. Pp. 197, pls. 33. 1893.
No. 5.* The Pollination of Pear Flowers. Pp. 110, pls. 12. 1894.
No. 6.* Bordeaux Mixture as a Fungicide.
No. 7.* The Effect of Spraying with Fungicides on the Growth of Nursery Stock. Pp. 41, figs. 17. 1894.

Farmers' Bulletins:

No. 4. Fungous Diseases of the Grape and their Treatment. Pp. 12. 1891.
No. 5. Treatment of Smuts of Oats and Wheat. Pp. 8, pl. 1. 1892.
No. 7. Spraying Fruits for Insect Pests and Fungous Diseases. Pp. 20. 1892.
No. 15.* Some Destructive Potato Diseases. Pp. 8, figs. 3. 1894.
No. 17.* Peach Yellows and Peach Rosette. Pp. 20, figs. 7. 1894.
No. 30.* Grape Diseases on the Pacific Coast. Pp. 15, figs. 3. 1895.
No. 33.* Peach Growing for Market. Pp. 24, figs. 21. 1895.

Circulars:

No. 10. Treatment of Nursery Stock for Leaf Blight and Powdery Mildew. Pp. 8, figs. 2. 1891.
No. 11. Inquiry on Grape Diseases and their Treatment. P. 1. 1891.
No. 12. Inquiry on Rust of Cereals. P. 1. 1891.
No. 13. Inquiry on Peach Leaf Curl. Pp. 3. 1893.
No. 14. Inquiry on Rusts of Cereals. Pp. 3. 1894.
No. 15.* Treatment for Sooty Mold of the Orange. Pp. 4. January 2, 1895.

LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY,
Washington, D. C., July 12, 1895.

SIR: I have the honor to transmit herewith a bulletin on the principal diseases affecting citrous fruits in Florida and to recommend its publication as Bulletin No. 8 of this division. The bulletin embodies the results of investigations carried on during the past three years by Mr. Walter T. Swingle and Mr. Herbert J. Webber, and is intended to present in a brief way the main facts so far discovered in regard to the principal diseases. Investigations of some of the diseases are still under way, and it is hoped to publish the results of this work more in detail at some future time.

The orange industry in Florida is of prime importance, and the crop is one of great value also to the States of Louisiana and California. In Florida there is probably no less than $50,000,000 invested in the business, fully twenty thousand people being dependent upon it for support. So far the annual crop has been almost five million boxes, valued at as many million dollars. The annual losses in Florida alone from all the diseases here described will probably amount to half a million dollars.

Respectfully,

B. T. GALLOWAY,
Chief of Division.

Hon. J. STERLING MORTON,
Secretary of Agriculture.

LETTER OF SUBMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY,
Subtropical Laboratory, Eustis, Fla., April 11, 1895.

SIR: We submit herewith manuscript for a bulletin giving brief descriptions and illustrations of the principal diseases of citrous fruits, with particular reference to their occurrence in Florida. In the case of each disease discussed a short statement is given of the most practical means of combating it. The work summarized has been carried on mainly in Florida during the past three years. Our aim has been to give as concisely as possible a clear account of the diseases, in order to promote speedy and certain identification of them by all interested.

Respectfully,

WALTER T. SWINGLE,
HERBERT J. WEBBER,
Assistant Physiologists and Pathologists.

Mr. B. T. GALLOWAY,
Chief of Division.

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THE PRINCIPAL DISEASES OF CITROUS FRUITS IN FLORIDA.

By Walter T. Swingle and Herbert J. Webber.

INTRODUCTION.

It is the purpose of this bulletin to give, in as brief and concise a manner as possible, an account of some of the principal diseases of citrous fruits, especially those occurring in Florida. The following are the diseases which we will endeavor to describe and illustrate: Blight, die-back or exanthema, scab or verrucosis, sooty mold, foot rot or mal-di-gomma, and melanose.

The diseases of citrous fruits have received more or less attention from the Department, through the Division of Vegetable Physiology and Pathology, since the year 1886. In 1891 Prof. L. M. Underwood was sent to Florida to make a preliminary study of this subject. Later the same year one of the writers, with Dr. Erwin F. Smith, was sent to Florida to carry on further studies, especially on blight, and the following spring the former returned to continue the work. In the fall of 1892 a slightly increased appropriation enabled the Department to station both writers regularly in Florida. A laboratory especially erected for the purpose was donated by the citizens of Eustis, Fla., and this point was made our headquarters. Since the completion of the building both laboratory and field investigations have been carried on continuously, with highly gratifying results. Melanose, an entirely new disease, has been studied and remedies for it discovered. Satisfactory remedies or preventives have also been found for all the other diseases mentioned above, foot rot being the only one which could be said to be under control when the work was commenced. Much information has been collected in relation to the causes of the various diseases and their effects on the plants attacked.

It is gratifying to record here the uniformly kind and generous treatment we have received from the fruit growers of Florida, without whose aid and support much of the work here summarized would have been impossible.

BLIGHT.

This disease, also called wilt and leaf curl, is found only in Florida, and so far as known at present is incurable. Nearly all citrous fruits are liable to it, but in different degrees. Trees grown on light hammock

soil are most susceptible, but no locality in the State is entirely exempt. The malady has been known for at least twenty and possibly twenty-five years. The first reliable account of it, however, was published in 1891[1] by Prof. L. M. Underwood.

Blight never attacks trees until they have attained considerable size and have begun to bear fruit. In any given grove usually only a small per cent of new cases occur each year, but the fact that the disease is apparently incurable and that it attacks the oldest and most vigorous and fruitful trees in the grove renders it one of the most destructive maladies known. It is widely distributed over the State, occurring in the oldest and best groves and on the land best suited for profitable orange culture. The affected trees do not die at once, but apparently revive when the rainy season commences. In this way false hopes are aroused and the owner waits for years before he finally removes the blighted trees and replaces them with healthy ones. Much time and money have been wasted on supposed cures, the worthlessness of which does not become apparent until after several years' trial. In some localities from 1 to 10 per cent of the trees blight annually. The annual loss resulting from this disease in Florida is from one to two hundred thousand dollars. Within the last ten years it has caused losses probably amounting to several million dollars.

Symptoms.—Blight usually appears very suddenly and on trees that have previously seemed perfectly healthy. The first symptom is a wilting of the foliage, as if the tree were suffering from drought (fig. 1). At first the wilting is slight and can be plainly seen only on hot, dry days; but it soon becomes very pronounced, and often continues so during the wet season in summer, when rains are almost a daily occurrence. Most cases of blight appear in early spring, from February to April, which is usually a dry season. Sometimes, however, cases occur in midsummer, when the ground is thoroughly wetted every few days. After the wilting becomes severe the foliage begins to drop, and in a few weeks to a few months, according to the severity of the case, the affected branches shed nearly all their leaves. In many cases the whole top of the tree is attacked at one time, but very often only a single branch shows the disease at first. In such cases, however, the entire tree soon becomes affected.

As soon as the rainy season begins the trunk and larger branches put forth numerous water sprouts, which grow rapidly and at first seem to be perfectly healthy. Eventually, however, these sicken and gradually die back. The branches which first showed the blight usually retain for a year or more some foliage, which is abnormally small and of a dingy green color. New growth is very sparse and does not produce normal-sized leaves. Such branches often show green twigs all over, even when nearly leafless. In the spring following the first wilting (unless it occurs late in winter, when it is not until the second

[1] Journal of Mycology, Vol. VII, pp. 32–34.

spring following) these branches, though often nearly leafless, flower very profusely and continue blooming for ten days to three weeks after the normal period of flowering has passed. Unlike the lemon, the flowering season of the orange is very definite, and usually is not longer than two weeks. This profuse and late bloom consists of small flowers, which almost never set fruit. In fact, very little fruit is produced by a tree after it is attacked by blight. Trees bearing a full crop may sometimes be attacked late in summer and

FIG. 1.—Orange blight on common sweet orange (*C. aurantium*); diseased and healthy branches from adjoining trees. Photographed May, 1894, while attached.

mature their fruit, but it is only in case of late attacks that any considerable amount of fruit can be seen on diseased trees. Fruit borne by blighted trees is usually undersized, but otherwise is apparently normal.

The contrast in the amount of fruit produced by trees attacked by blight and those affected with mal-di-gomma is very striking, trees suffering from the latter disease often bearing an unusually heavy crop.

In very severe cases of blight the trees succumb so suddenly that the leaves do not fall, but simply wither and turn brown on the twigs.

This is also frequently the case with a single branch. In such cases the trees usually die outright in a few weeks and never put out any new growth from the trunks. Again, a single branch may wither as suddenly. In the great majority of cases, however, a vigorous new growth pushes out from the trunk at the beginning of the rainy season and at first it would seem as though the tree would recover. Sometimes such sprouts continue growing vigorously two years or more, but sooner or later they show small and usually yellowish leaves and begin to decline. Often, too, such shoots wilt and show all the symptoms of a fresh case of blight. Ordinarily the tree continues to decline gradually, and is finally removed before it dies, to make place for a new tree. Again, cases may linger ten years or more, making a slow, sickly growth, and even bearing a little fruit. Cases of real recovery from genuine blight are, however, almost entirely unknown, although hundreds of growers have been deceived by the vigorous growth of water sprouts sent out by blighted trees after the first wilting.

A most remarkable fact is that the roots of blighted trees invariably seem to be entirely healthy. The vigorous growth of water sprouts they support shows that they are capable of considerable functional activity.

No anatomical features which are characteristic of blight have yet been found. Under the highest powers of the microscope the tissue of every organ of blighted trees appears to be normal, which is in striking contrast to foot rot and die-back. The physiological activity of the leaves and branches, however, is very much deranged, as has been proved by experiments on the loss of water from blighted twigs.

Varieties of trees attacked.—Almost all citrous fruits are attacked by blight, although some sorts are nearly exempt. Common oranges (*Citrus aurantium*), tangerines and mandarins (*Citrus nobilis*), and grape fruit (*Citrus decumana*), in about the order named, are the most susceptible. Lemons blight less than any of the fruits mentioned, while limes and sour oranges, especially the latter, are almost exempt from this disease. Certainly not more than one sour orange tree in a thousand is blighted even in regions most liable to the malady. Curiously enough, the sort of stock used appears to have no influence in increasing or diminishing the susceptibility of trees to the disease. Common oranges budded on sour orange roots are apparently as liable to blight as are sweet seedling trees.

Situations most liable to the disease.—Although blight attacks citrous fruits growing on all kinds of soil, it is most common on trees growing on very light, sandy hammock[1] (Pl. II). Such soils are usually composed almost wholly of sand, with an admixture of decaying vegetable matter; sometimes, however, they are underlaid at a depth of from 4 to 12 feet with clay or hardpan (sandstone). Trees growing on clayey

[1] Hammock land is that which was originally covered with hard woods, especially live oak, magnolia, hickory, etc.

hammock or high pine land[1] are almost exempt from the disease. On flatwood land[2] the trees are less susceptible than those on light hammock, but more susceptible than those on high pine lands.

As the blight is most prevalent on the best orange lands, with the exception of clayey hammock, which is rare, it is obviously impracticable to prevent the disease by planting on lands least subject to it.

Cause.—So far the most diligent search, both in the field and in the laboratory, has failed to reveal the cause of blight. Judging from what is known of the disease, it is not improbable that it is caused by some minute parasitic organism, but the character of the soil to a large extent governs the entrance and spread of the organism. In many respects blight strongly resembles peach yellows, the exact cause of which is also unknown. Certain it is that blight can not be attributed directly to cold, drought, wet weather, close proximity of hardpan, or improper fertilizers, as is often erroneously believed.

Is blight contagious?—As before stated, this malady in many respects resembles peach yellows, which latter disease is contagious by budding as has been proved by experiments. Numerous experiments are under way to determine whether blight can be introduced by buds on the roots or tops of trees, but so far no conclusive results have been obtained. The disease attacks trees in groups, as is obvious in groves where it exists. A year or two after a tree is blighted it is a common thing to see the adjacent trees show the blight on the limbs next to the diseased tree. All these circumstances strengthen the belief that the disease is of a contagious nature.

Preventive measures.—Experience has taught that it is not only useless but dangerous to attempt to cure blighted trees, since it is probable that the disease is contagious, and that a diseased tree left in the grove may infect surrounding healthy trees. It is by all means the safest and at the same time the most profitable plan to dig up and burn all blighted trees as soon as they appear and plant new trees in their places. In many instances it would seem that prompt destruction of trees as soon as attacked has decidedly reduced the number of new cases as compared with adjoining groves similar in all respects, but where the diseased trees were allowed to remain. In peach yellows the prompt extirpation of cases as they appear is the only known way of preventing the spread of the disease.

In replanting, good-sized trees are preferable to small trees, as the latter are liable to be overshadowed and starved out by the large trees surrounding them. The diseased trees when dug out can be either

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[1]Land covered with scattering *Pinus palustris* and a few trees of *Quercus cinerea* and *Q. catesbæi*, all growing so far apart as to allow grass to grow so thick that it is burned off annually, thus preventing the growth of underbrush.

[2]Much like high pine land, but low and flat, with a subsoil near the surface, and more undergrowth, composed largely of scrub palmetto (*Serenœa serrulata*) and Ericaceæ.

hauled away and burned, or better, cut up and burned on the spot, thus avoiding any possibility of spreading the disease through the grove. It has been abundantly proved that trees planted where blighted ones have stood are not more likely to contract the malady than any others in the vicinity, and in no case are they liable to blight before they begin to bear.

The practice here recommended of extirpating all cases as they appear is now largely followed by those who have had the most experience with blight and who know the uselessness of supposed remedial treatments. In all badly infected regions concerted action is highly desirable, but even if this can not be secured the grower should not be deterred from eradicating the diseased trees from his own grove. Aside from the fact that such a course probably lessens the spread of the malady, it is the cheapest and best policy.

DIE-BACK OR EXANTHEMA.[1]

The disease of the orange and other citrous fruits commonly known as die-back is widely distributed throughout the orange region of Florida, but is not known to occur in any other part of the world. The name "die-back" originated from the behavior of trees affected, a few inches of the vigorous new growth dying back in early spring. The disease is not much feared by growers, because it is apparently not contagious; but while the damage it causes in a single grove may be slight, the total loss, on account of its very widespread occurrence, is nearly as great as that resulting from any other disease affecting the orange. The malady is well known to most orange growers, but is generally poorly understood. It was first accurately described by J. H. Fowler[2] in 1875. When and where it first appeared has not yet been determined. Growers have known of its occurrence for years, presumably ever since orange culture became common in the State.

The damage caused by die-back is much greater than is usually estimated. Many groves have suffered for years from slight attacks of the disease, the damage being caused mainly by the excessive dropping of the fruit and by the coarseness and staining of that which remains on the trees. In some severe cases, due to improper fertilization and cultivation, groves have been badly injured and almost the entire crop of fruit lost. Frequently much loss is incurred by planting trees on improper soils and continuing to cultivate and fertilize them for years after they contract the disease. Almost every grove in the State has a few cases of this disease. Trees growing in the vicinity of

[1] From the Greek *εξανθημα*, meaning an eruption or pustule.

[2] Fowler, J. H., On the Die-back in Orange Trees (Proceedings of the Florida Fruit Growers' Association, annual meeting January, 1875; reprinted: Florida, its Scenery, Climate, and History, Sydney Lanier, 1876, J. B. Lippincott & Co., Philadelphia, Appendix, pp. 281–290).

stables, chicken houses, privies, etc., are the ones generally affected, and also those growing on the margins of lakes, or on low, wet, poorly drained soils.

FIG. 2.—Die-back. *a*, twig of sweet orange (*C. aurantium*) from which the leaves have fallen and a portion is dying back; *b*, swellings on young sweet orange twig caused by gum pockets in the wood; *c*, sweet orange with an abnormal number of buds developed in the leaf axils; *d*, lemon (*C. limonum*) twig with abnormal number of buds developed. *a* and *b* slightly reduced, *c* and *d* natural size.

The diminished productiveness of trees badly affected with die-back, together with the splitting and falling of much of the fruit and the disfigurement and coarseness of that which does develop, makes such trees almost worthless. The malady causes great loss of fruit, renders more of poor quality, frequently permanently stunts the tree, and eventually kills it. The annual loss resulting from die-back in Florida may be conservatively estimated at about $100,000.

Symptoms.—Die-back has probably more characteristic symptoms than any known plant disease, principal among which are the following:

1. The ends of the very rapidly growing shoots turn yellowish before maturing, and finally become stained reddish-brown in patches or throughout. This appearance is caused by a deposit in the outer cells of a reddish-brown resin-like substance. This yellowing and staining of the twigs, which is very general on the new growth all over the tree, is followed by the dying back of the affected twigs for a short distance, usually 3 to 6 inches (fig. 2, *a*). The reddish stain may occur on the twigs back of the point to which they die, and, indeed, may spread in irregular patches, more or less over the entire new growth.

2. On the new growth (most frequently at the nodes, but sometimes in the internodes) there occur comparatively large swellings, caused by gum pockets formed in the wood (fig. 2, *b*). These pockets frequently become quite marked.

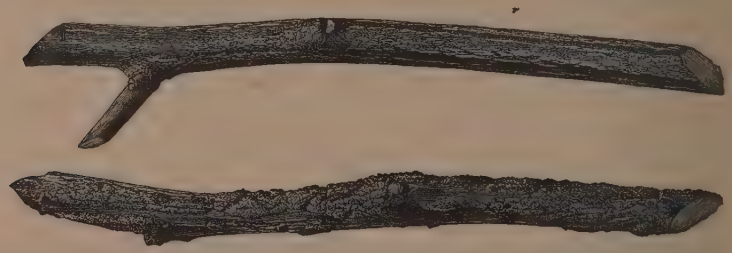

FIG. 3.—Orange twigs showing effects of die-back; upper healthy, lower diseased. Natural size.

3. Eruptions, caused by the bursting of the bark, very commonly occur on new and old twigs (fig. 3, lower twig, and Pl. III, fig. 3). In such cases the tissue swells up, protrudes from the rupture, and becomes stained by the reddish-brown, resin-like exudation, which is so characteristic of the disease. These eruptions are very numerous, and in badly affected trees many limbs, from an inch in diameter down to the smallest, become thickly studded with them. This character almost invariably accompanies the disease and is present at all seasons of the year, so that it may probably be regarded as the principal symptom. Trees may be slightly affected, however, and not show this symptom.

4. In diseased trees rapidly grown young shoots often droop in a characteristic manner. After starting to push the twigs gradually bend downward and the ends turn up a little, giving the twigs a slightly S shaped curve. This, however, is not always a symptom of die-back, being occasionally seen in perfectly healthy trees.

5. Young twigs frequently develop an abnormal number of buds in the axils of the leaves, where, under normal conditions, only one or two are formed (fig. 2, *c* and *d*). This overproduction of buds is often followed by a gummy exudation at these points. Several of these buds from one node may develop into branches, which, in connection with the short internodes, frequently give the new growth a somewhat fascicled appearance. This causes a very dense foliage, and after the new growth, which produces this fascicled appearance, has died back the tree takes on a very regular appearance, as if it were clipped. This is very characteristic of cases in the middle stage of the disease. In a later stage large limbs die back, leaving around the trunk a dense growth of small water sprouts with large leaves. These shoots in turn become stained with the characteristic reddish-brown exudations and eruptions and finally die back. In this stage of the disease, which is one of the last, the tree presents a very ragged appearance, many of the large limbs being dead (Pl. IV).

6. The leaves on trees affected with die-back are rather larger and generally longer and more pointed than those on healthy trees. This symptom, however, is not very noticeable.

7. The foliage of diseased trees is always a very dark green; indeed this color, so much desired by some growers, indicates that the grove is on the verge of showing the disease.

8. Frenching or spotting of the leaves with white and green frequently occurs in the more advanced stages of the trouble, but can hardly be considered a symptom.

9. Slightly swollen, stained spots often occur on leaves of trees in a medium stage of the disease. Any slight mechanical injury or injury due to the attacks of the six-spotted mite (red spider), which works in definite spots, is liable to be followed by a swelling of the leaves at the points injured, accompanied by the characteristic stains, thus forming brown, swollen spots. These spots are evidently formed only in places where the leaves are injured.

10. The fruits of diseased trees early assume a pale, sickly green color, which is quite different from the dark-green color of normal fruits. Some fruits split and fall while in this condition, but by no means as many as fall in the next stage of the disease.

11. When the fruits reach a size of from 1 to 1½ inches in diameter they gradually change color, turning light lemon yellow and commonly showing a slight brown exudation in places on the rind (Pl. III, figs. 1 and 2). At this stage many fruits fall; this usually occurs after the appearance of the brown stains, but sometimes before. On trees slightly affected many of the fruits fall early, while on trees badly affected it is seldom that any fruits remain on the tree until they reach full size. The fruits usually split before dropping. At first a slight crack appears around the eye end or apex of the orange, accompanied by a slight gummy exudation (Pl. III, fig. 1). Finally a large split opens across

the fruit, exposing the segments and causing the orange to rot and fall (fig. 4).

12. Both the fruits which fall early and those which come to full maturity are usually more or less disfigured by irregular brown stains, similar to those occurring on the twigs. These stains frequently cover a large portion of the fruit, rendering it unsalable (Pl. III, fig. 2).

13. Slight swellings are sometimes found on the rind, particularly in the sour orange. These swellings are caused by gum pockets formed within the tissue of the rind. Very frequently a formation of gum also occurs in the segments immediately around the axis, generally near the seeds.

14. The fruit of trees affected with die-back usually ripens considerably earlier than that of adjoining healthy trees of the same variety.

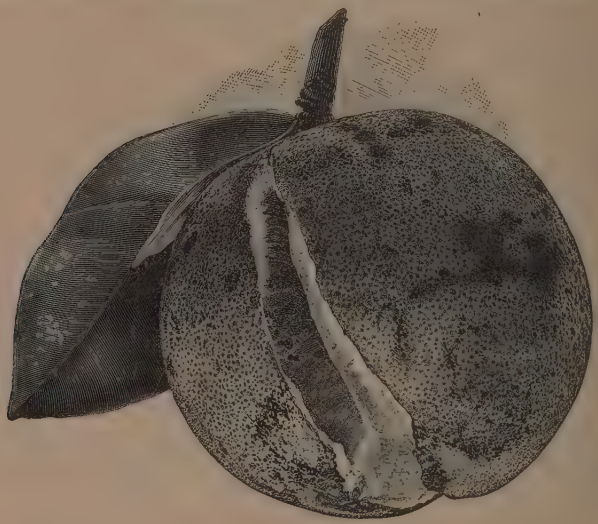

FIG. 4.—Orange fruit, showing effects of die-back.

As a rule, however, it is large, very coarse, thick skinned, and disfigured with brown stains, and in consequence often unsalable.

15. The roots of trees affected with the disease usually have a healthy appearance, but in severe cases, on improper soils, they frequently become ulcerated and die back for some distance, the dead ends rotting away. Roots which have died back frequently have large and somewhat swollen ends, from which later on a number of small roots frequently arise.

The order in which the symptoms appear and their severity vary greatly, but generally are as follows: The first sign of the disease is the unusually dark-green color of the foliage, rank growth, and large, thick-skinned fruit. These symptoms are soon followed by the staining and dying back of a few twigs, and by brown stains formed on some

of the fruits. The fruits developed are very prone to split and drop prematurely. In the first stage of the disease either the stained fruit, or the stained, dying twigs must be present to determine with certainty the presence of the malady. Trees affected with the disease may grow for years and show only one of these characters; in other cases all the symptoms may be present, but to a very slight extent, so that careful search must be made to find them. As the disease progresses the brown staining of the fruit and twigs becomes more abundant and the dying back of the twigs occurs all over the tree; eruptions form on the young and old twigs; nodal swellings, due to the gum pockets, become very abundant; and the tree assumes the dense foliage and regular outline described above. In this stage of the disease many fruits set, but they usually turn yellow, become stained, split, and fall before maturity, only a few, if any, reaching full size. Soon the gum eruptions extend to the old limbs and these die back. The rank new growth becomes limited to the center of the tree; here branches grow luxuriantly for a time, only to become stained and die back later. The tree then assumes the ragged appearance described above (Pl. IV). In this stage no fruits set, and, indeed, the tree has become so sick that no flowers are formed. This disease is not accompanied by profuse blooming, as is the case in blight; on the contrary, the tendency is to produce very little bloom. If the disease is allowed to continue unchecked the trees will ultimately cease to grow and finally die.

Cause.—The cause of die-back is not yet thoroughly understood. For several years experiments have been under way to determine whether various fertilizers may not produce the malady. Experiments have also been conducted in the laboratory with water cultures. In these experiments various forms of pure chemical manures were employed, the amounts used being under absolute control. From the results of these experiments and from extensive field observations in many parts of the State it seems highly probable that the disease is caused by malnutrition. In most cases it is probably induced by excessive use of organic nitrogenous fertilizers. As before stated, trees near stables, chicken houses, privies, etc., are very commonly affected by the disease. Heavy applications of cotton-seed meal, dried blood, or other highly nitrogenous organic fertilizers are frequently followed by the appearance of the trouble. Groves fertilized continuously with organic fertilizers rich in nitrogen are usually more or less affected with the malady, depending upon the quantity of fertilizer used. Whether the chemical manures, such as nitrate of soda or sulphate of ammonia, when used in excessive quantities, will finally produce the disease, is yet questionable, but all evidence indicates that they will not. In several experiments the excessive quantities of chemical manures used killed the trees outright, although no signs of the disease appeared.

A form of the disease known as soil die-back is very common and is very evidently independent of the action of any fertilizer. Certain

fields of limited area, which are low and poorly drained or underlaid with "hardpan" (a ferruginous sandstone), seem predisposed to produce the disease. Trees set out on such soils never develop normally, but contract die-back in its worst form. These frequently remain for years in a stunted condition, each year's growth as formed dying back. Such trees finally die if allowed to remain untreated. Often considerable loss is incurred by planting and fertilizing groves on these die-back soils. The symptoms of die-back are the same whether due to excessive fertilization or to improper soil conditions, and it is probable that the real cause will be found to be the same in both cases. Both forms of the disease appear to be greatly aggravated by excessive cultivation, which apparently destroys the surface roots and forces the tree to feed lower down.

Treatment.—When die-back is due to the excessive use of highly nitrogenous organic fertilizers, an effective remedy consists in simply ceasing to cultivate and allowing all weeds to grow. In fertilizing omit entirely all highly nitrogenous organic manures, but use about the normal quantity of potash and phosphoric acid. As the tree recovers a small amount of nitrogen should be given, preferably in the form of nitrate of soda or sulphate of ammonia, until the tree is brought up to its normal condition. If the disease is produced by the close proximity of privies, chicken houses, barns, etc., removing these will usually result in the recovery of the affected trees. In the case of barns which can not be removed it has been found effective in some cases to dig trenches between the trees and the barn to prevent the feeding roots from running under the former. Of course the caution in regard to the use of organic nitrogenous fertilizers given above is applicable in this case also. When the malady is caused by planting on die-back lands, treatments vary according to the character of the soil. If the grove is on low, wet soil, thorough drainage will usually be found an effective remedy without other treatment. If the soil is underlaid with hardpan, mulching the trees with pine straw, oak leaves, or something of this nature, and stopping cultivation will allow the feeding roots to develop near the surface and usually bring about a cure. The latter has been found an effective treatment in many instances. Good drainage is also beneficial in such cases.

SCAB OR VERRUCOSIS OF THE LEMON AND OTHER CITROUS FRUITS.

The introduction of this disease into the United States is comparatively recent. It first appeared in Florida about the year 1884 and spread rapidly over the State and to Louisiana. Although many thousands of trees affected with scab have been sent to California, it seems that the disease is unable to exist there permanently. The reason for this will appear later. The malady also occurs in Australia and Japan, from which latter country it was undoubtedly introduced into America. So far it is not known to occur in Europe or Africa.

The first account of the disease was published by F. Lamson-Scribner in October, 1886 (Bulletin of the Torrey Botanical Club, New York, Vol. XIII, No. 10, pp. 181–183), at which time Professor Scribner was Chief of the Section of Vegetable Pathology of the Department of Agriculture. A fuller account, with a colored plate, was published in the Annual Report of the Commissioner of Agriculture for 1886, pp. 120, 121. A disease undoubtedly the same was reported from Australia on orange and lemon leaves by Henry Tyron.[1]

The principal loss from scab occurs in Florida, where it often renders lemon groves so unprofitable that they are cut off and budded to other citrous fruits. In many cases a very large percentage of the fruit is rendered unsalable, sometimes one-third or even one-half being unfit for market. It also causes some injury to sour orange trees (before they are budded) when grown for nursery stock.

Scab, or a disease closely allied to it, occurs on very young fruit of the lime (*Citrus limetta*), and in some localities is often so severe as to entirely destroy the crop. For example, a grove in tropical Florida, capable of yielding 500 boxes of fruit annually, when attacked by this disease produced for several years only a few hundred fruits, and the majority of these fell off while still very young. In Louisiana it is said to have attacked Satsuma oranges; in Japan it causes considerable damage to orange groves situated on low, moist land; in Australia it is reported as causing orange and lemon trees to lose their leaves and to yield poor crops, badly affected trees often not setting a single fruit. Probably the annual loss from scab in the United States is not far from $50,000, most of the damage being done to the lemon in Florida.

Symptoms.—The leaves and fruit of trees affected with this disease show small, wart-like excrescences (Pls. V, VI). These excrescences are of various sizes, the diameter ranging from ½ mm. to 1 cm. (one-fiftieth to two-fifths of an inch), but usually being from 1 to 5 mm. They sometimes run together and cover a large portion of the leaf or fruit. In case the fruit is attacked while still very young the tissues below the wart grow more rapidly than normally. This causes the fruit to become covered with bumps, of irregular pyramidal shape. These grow proportionally with the fruit and on the mature fruit may sometimes be 1 to 2 cm. across and project out nearly the same distance. At first the warts look like small semi-translucent pimples, of a slightly lighter shade of green than the surrounding healthy tissue. In a few days, if the weather be favorable, the warts become prominent, assume a conspicuously light green color, and look watery. After this they become covered with a delicate fungus, which is at first gray, then dusky, and at last black. Finally the infected tissue covering the tips of the warts is cut off from the healthy tissue below by a formation of cork, and ultimately the cork formation becomes so abundant as to give a dingy white color to the old warts. The appearance and development of the warts

[1] Report on Insect and Fungous Pests, No. 1, Queensland, 1889, pp. 144, 145.

are much the same on the leaves as on the fruits. There is no formation of a bump below the wart. When the leaves are attacked while still very young much the same effect is produced as in the case of the fruit, the leaf surface bulging abruptly outward and causing the warts to appear seated on hollow, conical protuberances. The leaf is often considerably thickened where the wart is situated, and the persistence of the leaves for at least a year in most cases enables the cork formation to proceed further than is usually the case on the fruit.

Varieties of trees attacked.—Scab attacks only certain species of citrous fruits, the sour orange (*Citrus bigaradia*) being particularly subject to its ravages. It was first noticed in the United States on this host. Both leaves and fruits of affected trees are often severely injured. The greatest loss, however, is caused by its disfiguring the lemon. It attacks the fruits far more frequently than the leaves, and by causing the lemons to become bumpy and warty renders them valueless or nearly so. On the foliage it is never abundant enough to do serious harm. After the sour orange and lemon the Satsuma orange is most frequently attacked. This variety, probably a form of *Citrus nobilis*, comes from Japan. On this host scab rarely causes serious damage to the crop and is seldom seen on the foliage. In all probability the disease was introduced from Japan into the United States on this orange. In several localities in Florida the first appearance of scab on the sour orange and lemon was shortly after the introduction of Satsuma orange trees. The fact of its being usually inconspicuous on this host explains why it was not noticed first on this species.

Scab, or a disease closely allied to it, occurs on very young fruit of the lime (*Citrus limetta*), causing the fruits to fall while still very small. It has not been found on the older fruits or leaves of this species. It also occurs on the Otaheite orange, a variety of unknown origin, but apparently having some lemon ancestry. All the common sweet oranges (*Citrus aurantium*), the Kumquat (*C. japonica*), tangerine, mandarin, and king oranges (*C. nobilis*), grape fruit and shaddock (*C. decumana*) seem to be nearly if not quite exempt. Certainly no appreciable damage is ever caused to these sorts by scab. In Florida, however, it is said to occur occasionally on the tangerine and mandarin oranges. In Japan it appears to affect the ordinary cultivated oranges, which are largely varieties of *Citrus nobilis*. In Australia the disease is reported on orange leaves, but no information has been furnished as to whether or not any other sorts are exempt.

Cause.—Scab is caused by a minute parasitic fungus (*Cladosporium* sp.). So far as known this fungus is found only on the varieties of citrous plants subject to the disease in question. It is a very minute species and usually forms a delicate, dusky coating, only a few hundredths of an inch thick, on the surface of the wart. The colorless mycelial threads of the parasite creep about in the superficial layers of

the warts and give rise to tufts of erect, brown, branched, and multicellular fruiting branches or hyphæ. On these the dusky, spindle-shaped spores are produced. The spores are borne in abundance near the ends of the hyphæ, which often show numerous scars where spores have been detached. The spores are usually one-celled, but occasionally are two, and very rarely even three-celled. They are very minute, being only 8 to 9 by $2\frac{1}{2}$ to 4μ (about $\frac{1}{3\,0\,7\,0}$ inch long and $\frac{1}{8\,0\,0\,0}$ inch wide). The hyphæ are mostly 30 to 75 by 2 to 4μ. The spores germinate by pushing out a slender thread from the side.

Conditions governing infection of the host plant by the parasite.—It has been found that this fungus is remarkably sensitive to weather conditions and can fruit abundantly and spread rapidly only where the air is moist. In Florida the disease often makes no perceptible progress for weeks during the dry spring, but if a few days of damp weather come on, it suddenly spreads and develops very rapidly. Groves in low, moist situations are more subject to scab than those on high and dry lands. The fact that the fungus depends so closely on moist weather for its proper development and spread doubtless explains its almost total absence from California, where the atmosphere is much drier during the growing season than it is in Florida.

Another important condition governing infection is that the tissue must still be growing to be subject to the invasion of the parasite. The period of greatest danger to both leaves and fruits is when they are young and tender and growing rapidly. This explains why old lemon and sour orange fruits are not badly deformed when attacked by the fungus after the moist weather of summer sets in.

Treatment.—During the spring and summer of 1894 extensive experiments were carried on by one of the writers to discover, if possible, means of preventing scab on the lemon. Owing to the irregular blooming of the lemon, the prevention of the disease was found to be a difficult undertaking. However, it was demonstrated that Bordeaux mixture and ammoniacal solution of copper carbonate, if properly applied, are efficient. The former is very effective against the fungus, but is more or less injurious to the fruit and foliage of the lemon, while the latter is almost an absolute preventive of the disease and causes very little if any injury to the tree.

It was found highly important that all infected fruits be removed from the tree and from the ground beneath before blooming begins. This measure is absolutely necessary to insure the success of any treatment, and is of itself a great aid in checking the disease. All sour orange trees or sprouts from sour stocks should also be removed from the vicinity of lemon trees, since they are even more subject to scab than the lemon, and because not only the fruit but also the leaves can support a luxuriant growth of the fungus.

The disease can be prevented, to some extent, by planting the trees on dry soil and in localities having little rainfall during and immedi-

ately after the blooming season. Directions for treating the disease are briefly as follows:

1. Carefully remove and burn or bury all diseased lemon fruits, however small, either on the trees or on the ground. Cut down and destroy all sour orange trees or sprouts from sour stock in the vicinity of the lemon trees.

2. Prepare ammoniacal solution of copper carbonate as follows: Take 5 ounces of copper carbonate and stir up with about a pint of water to a thick paste; then dilute with 1½ gallons of water in a wooden pail. Stir vigorously and at the same time add slowly 2 pints of strong ammonia[1] or 5½ pints weaker ammonia water.[2] Stir until all is dissolved, or at least all but a few granules, and then dilute with water to 50 gallons.

3. Apply the ammoniacal solution with a pump giving a good pressure and furnished with a Vermorel nozzle. The initial spraying should be made when the first young fruits are exposed by the falling of the flowers, the second spraying usually after two or three weeks, a third two or three weeks later or when blooming is nearly or quite over, and a fourth when the fruits are of a size ranging from that of a pea to that of an olive. If necessary a fifth and even a sixth spraying should be made after particularly wet weather. In most cases four and often five sprayings are absolutely necessary. By carefully watching for the appearance of warts on the fruit, particularly during moist weather, the grower can determine when to spray and whether any spraying is necessary after the third application.

4. Direct the spray so as to coat all the young fruits evenly, but thinly. It is not necessary to spray the leaves, but it will not be possible to avoid wetting them when spraying the fruit.

5. Watch for scale insects, and if they appear in great numbers use resin wash, kerosene emulsion, or other insecticide. This caution is necessary because in some cases where trees are sprayed with Bordeaux mixture the fungous parasites of the scale are killed, and consequently the scale insects multiply very fast. As yet no such effect has been observed when ammoniacal copper carbonate was used, but the possible danger from this source should be borne in mind.

6. If preferred Bordeaux mixture can be used in place of the ammoniacal solution of copper carbonate. In preparing the Bordeaux mixture take 6 pounds of copper sulphate and 3 pounds of lime; add 25 gallons of water to each, then mix, and add 6 pounds of dissolved soap to the mixture. This spray must be applied with care, giving the trees only a thin coating, otherwise the youngest foliage may be injured or scale insects induced.

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[1]Aqua ammoniæ fortior (28 per cent) of druggists.

[2]Aqua ammoniæ (10 per cent) of druggists.

SOOTY MOLD.[1]

Sooty mold of the orange, or smut,[2] as it is sometimes erroneously called, is a malady which frequently causes serious damage. The fungus producing it is of saprophytic habit, deriving its nourishment from the sweet fluids (honeydew) secreted by certain insects, the attacks of which it invariably follows. As the honeydew falls it strikes principally on the upper surfaces of the leaves and exposed branches and upper portions of the fruit (the stem end, as the fruits are pendulous), and it is on these portions that the sooty mold grows. It develops also to some extent on the lower surfaces of the leaves, but is not so abundant here. In Florida sooty mold follows principally the attacks of the mealy wing or white fly (*Aleyrodes citri* R. & H.), wax scale (*Ceroplastes floridensis*), mealy bug (*Dactylopius citri*), orange plant louse or aphis (*Aphis gossypii* Glover), etc., and spreads as these insect pests spread. It is only where it follows the mealy wing, however, that it becomes serious. In this State it is estimated that the loss it causes is not far short of $50,000 annually.

Besides occurring on all varieties of citrous fruits, sooty mold is frequently found on a number of wild plants in Florida. It is particularly abundant on the gall berry (*Ilex glabra*), red bay (*Persea carolinensis*), and magnolia. On the gall berry it follows attacks of the wax scale (*Ceroplastes floridensis*), which also infests the orange.

Sooty mold is probably common in all orange countries of the world. In California it causes much damage and is considered a serious malady. There it follows chiefly the black scale (*Lecanium oleæ*) and the cottony cushion scale (*Icerya purchasi*). In Louisiana it is very common on the orange, following chiefly, as in Florida, the mealy wing and wax scale. It is also quite common in Spain, Italy, and many other orange-growing countries.

Symptoms.—Sooty mold may be readily recognized by the dense sooty-black membrane which it forms over the fruit and upper surfaces of the leaves (Pl. VII, fig. 1). This membrane is made up of the densely interwoven, branched mycelial filaments (threads) of the fungus, the individual filaments of which can in some cases be distinguished with a hand lens. When isolated the filaments are seen to vary in color from olive green to dark brown. They are at first loosely interwoven, but gradually become very numerous and crowded. Finally they become cemented together, forming a dense, compact membrane. The fungus, as nearly as can be determined, is entirely

[1] Sooty mold of the orange is probably produced by several different species of the genus Meliola. The forms known as *Meliola penzigi* and *Meliola camelliæ* appear to be the most common in Florida. In publications in this country the fungus has usually been referred to *Capnodium citri* and *Fumago salicina*. The disease is known in Italy under the names fumaggine, morfea, nero, etc., and in Germany as Russthau.

[2] Smut is the name very generally applied to diseases produced by the true smut fungi (*Ustilagineæ*).

superficial. Small projections occur on the filaments, but no proof has been found that these penetrate the tissue of the leaf. Apparently they are merely organs of attachment. Large disks (hyphopodia) are also frequently developed, which evidently serve as organs for attaching the mold to the leaf. Reproductive bodies of several forms are developed in great abundance, and these are easily carried from tree to tree or from grove to grove through the agency of the wind, insects, birds, or animals.

This disease injures the plant by interrupting the process of assimilation. This is brought about by the cutting off of light and by hindering the passage of necessary gases in and out of the plant. The accompanying insects further injure the plant by sucking the nutritious juices from the cells of the leaf. The growth of the tree is usually greatly retarded, and in serious cases is frequently entirely checked until some relief is found. The blooming and fruiting are commonly light, and in very bad cases are wholly suppressed. In slight droughts the leaves wither quickly and curl up, resembling those on blighted trees. The young fruit becomes covered with the sooty mold and is retarded in its development, frequently never reaching complete maturity. It is usually smaller and less juicy than that normally developed, and remains very insipid. It does not change to the normal bright orange color of mature fruit till very late, and if the membrane of the sooty mold covering it is quite thick the rind remains somewhat green, apparently for an indefinite period, rendering the fruit unsalable. The black coating formed by the sooty mold renders the fruit unsightly and unsalable until it is thoroughly washed, which necessitates a considerable expenditure of time and labor. Even when carefully washed, a process which injures the keeping quality of the fruit, much of it being still small and green is unfit for market.

Treatment.—Where sooty mold followed the attacks of the orange mealy wing, spraying with resin wash or fumigation with hydrocyanic acid gas was found to be very effective. When resin wash[1] is used the best time for treatment is in winter, between December and the first of March. During this period the mealy wing can not fly away

[1] The following is the formula for resin wash: Resin, 20 pounds; caustic soda (98 per cent), 4½ pounds; fish oil (crude), 3 pints; water to make 15 gallons. Place the resin, caustic soda, and fish oil in a large kettle. Pour over them 13 gallons of water and boil till the resin is thoroughly dissolved, which requires from three to ten minutes after the materials begin to boil. While hot add enough water to make just 15 gallons. This may be most readily accomplished by taking a tight keg or other tall receptacle and measuring into it 15 gallons of water. Then plainly and permanently mark the height to which the 15 gallons reach. After boiling the hot solution may be poured directly into this measuring keg and sufficient water added to bring it up to the 15-gallon mark. This serves as a stock preparation.

When this stock preparation cools, a fine, yellowish precipitate forms and settles to the bottom of the vessel. The preparation must therefore be thoroughly stirred each time before measuring out to dilute, so as to uniformly mix this precipitate with the clear, dark, amber-brown liquid, which forms by far the larger part of the

to escape the spray, being in the mature larval or pupal stage and fixed immovably to the lower surface of the leaf. Furthermore, to be thoroughly effective, the resin wash must remain on the trees at least one or two days, and as this is usually a dry season it is not liable to be washed off soon. If thoroughly done, three or four sprayings during the period mentioned, at intervals of one to two weeks, will be found an efficient treatment. It is probably best to delay the sprayings until the fruit has been removed. Should it be found necessary, treatments may also be made during May and the first half of June, and again during the latter part of August and first of September.

In spraying it is important to wet thoroughly the under surface of every leaf. In treating this disease it has been found a good practice to trim the trees within, about the trunk and main limbs, thus leaving the greater part of the foliage near the outer parts of the tree. This greatly facilitates spraying, which must be done largely from under the tree, the spray being directed outward in order to wet the lower surfaces of the leaves. Where trees are trimmed out in this way an abundance of water sprouts usually spring up on the main limbs. The mealy wing generally lays its eggs on these in great numbers, and after a brood of mature winged insects have disappeared it is a good practice to prune off these water sprouts and burn them. In this way great numbers of these insects may be destroyed at slight expense.

Fumigation with hydrocyanic acid gas, in the way it is generally used, is also a very effective remedy. One treatment during the year, if properly made, should be sufficient. In the case of fumigation the treatment should be made some time between December and the first of March. During this period the temperature is usually much lower than at any other time, and this is a feature of importance. In treating this disease it has been found more effective to allow the gas to act for a slightly longer period than usual, say about forty minutes.

A parasitic fungus, *Aschersonia tahitensis*, has been found which attacks and destroys the larvæ and pupæ of the mealy wing, and bids fair to be of great aid in combating this pest. It forms small, wart-like,

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stock preparation. An instrument like a churn dasher, without perforations, greatly facilitates rapid and thorough mixing. When desired for use, take one part of the stock preparation to nine parts of water. If the wash be desired for immediate use, the materials, after boiling and while still hot, may be poured directly into the spray tank and diluted with cold water up to 150 gallons. This requires the addition of about 135 gallons of water.

If a fluid stock solution is preferred, the wash may be prepared as follows: Place the same proportions of resin, caustic soda, and fish oil in the kettle and pour over them from 15 to 17 gallons of water. Boil until the resin is thoroughly dissolved and then dilute with cold water, while the solution is still very hot, to exactly 21 gallons. To get this exact amount the barrel may be prepared and marked in the manner already described. This will form a clear, dark, amber-brown solution, which at ordinary Florida temperatures will remain perfectly fluid. For use dilute the whole formula to 150 gallons or use in the proportions of one part of the stock solution to six parts of water.

conical pustules, from 2 to 3 mm. in diameter. At first these are white or orange yellow throughout, but in the mature stage the spore masses become orange red (Pl. VII, fig. 2). This fungus is frequently found in groves affected with sooty mold. It dots the under surfaces of the leaves, and may occasion alarm if its nature is not understood. Unless examined in an early stage of development, no trace of the mealy-wing scale can be discovered without microscopic study.

When sooty mold follows attacks of the wax scale, mealy bug, or orange aphis, thorough sprayings with the resin wash or standard kerosene emulsion will be found effective. The time when the treatment should be made is not important in these cases, but if the resin wash is used a dry season should be selected, when the work will not be rendered uncertain by the liability of rainfall.

FOOT ROT[1] OR MAL-DI-GOMMA.

Foot rot or mal-di-gomma is a disease chiefly of the orange and lemon, and is probably more widespread than any other citrous malady. It is known to occur in almost all countries where the orange is cultivated, but so far as known appeared first in the Azores Islands, where it was very severe. According to the statement of Fouque,[2] it was first noticed in this group in 1834, on the island of San Miguel, where it seems to have originated. From that time until 1840 he estimates that fully one-fourth of the trees were destroyed. It reached its greatest severity on the island in 1840; in 1842 it began to decrease, and in 1873 it had ceased to be very serious. F. Alphonso[3] says that according to general report the malady appeared in Portugal in 1845, in Hyeres in 1851,[4] in Lago di Garda in 1855, and in Messina in 1863. According to Briosi[5] the disease first appeared in Sicily in 1862, and afterwards spread to Naples, Liguria, and Lago di Garda, everywhere destroying orange and lemon trees by thousands. Professor Wöhler (mentioned in Briosi's monograph referred to in foot-note) found the malady very destructive on the Balearic Islands in 1871. Statements differ in regard to the first appearance of the disease in Florida, but it seems to have been noted here some eighteen or twenty years ago. Dr. A. H. Curtis[6] says: "It appeared about nineteen years ago, though few

[1] An account of this disease, prepared by B. T. Galloway, was published in Part II of Bulletin No. 8 of the Division of Botany, U. S. Department of Agriculture.

[2] Voyages geologiques aux Açores, III, Les Cultures de S. Miguel (Revue des deux Mondes, Paris, Apr. 15, 1873, p. 837).

[3] Alphonso, F., La coltivazione degli aranci nelle Azzorre (Annali di agricoltura Siciliana, Vol. V, 1873, p. 311).

[4] Rendu, M. V., Note sur la maladie des oranges d'Hyères, Extrait (Commissionaires Jussieu, Gaudichaud' Decasne) (Compt. Rend., t. 33, 1851, pp. 681–683).

[5] Briosi, Giovanni, Intorno al mal di gomma degli agrumi (Fusisporium limoni, Briosi) (Atti della R. Acad. dei Lincei, Roma, ser. 3ª, Vol. II; Memoria della classe di science fisiche ecc, meeting of May 5, 1878, pp. 485–496).

[6] Curtis, A. H., Sore shin or gum disease (Fla. Expt. Sta. Bull. No. 2, June, 1888, pp. 29–35).

people remember to have observed it earlier than 1880." The disease is widely distributed in Florida and has by no means run out, but, on the contrary, seems to be gradually spreading. It has also appeared in Louisiana and California, where, in places, it is said to be very destructive.

The damage caused by foot rot is very great and without question much more than that caused by any other orange disease. The first season after the trees are attacked they may bear an unusually large crop of fruit, but this is generally the last full crop produced. By the next season the tree is either killed or else so reduced that it can not support much fruit. Sometimes trees are nearly girdled in the space of a few months. Whole groves have been entirely destroyed in the course of a few years. Briosi describes its effect in Italy and Sicily as being most serious; he estimates the damage done in Italy from 1862 to 1878 at more than $2,000,000. In Florida many fine bearing groves have been almost totally destroyed, but the malady does not appear to be so severe here as in some foreign countries. The annual damage it causes in Florida is estimated at about $100,000.

Symptoms.—The first symptom of foot rot is an abundant exudation of drops of gum on the trunk of the tree near the base. This occurs over a limited portion of the bark in the first stages of the disease, and may appear in one or several distinct patches. In this stage the bark will be found to be discolored, having become brownish, and to contain numerous cavities filled with gum. The inner bark becomes watery and more or less rotten, and has a very disagreeable, fetid odor. As the malady develops the demarkation between the healthy bark and the diseased patches becomes very apparent. The plant endeavors to throw off the disease and a separative layer is formed between the healthy and diseased portions. The patch of diseased bark thus delimited dries up, the edges break away where the separative layer is formed and gradually curve up in drying. Finally the patches of diseased bark are thrown off (fig. 5). The death and decay of the tissues caused by the disease extend through the bark and apparently for some distance into the wood. The cambium layer, the most vital part of the tree, situated between the bark and the wood, is destroyed, and when the bark is thrown off there is no possibility of new bark growing over that portion. The patches of bark which first become diseased are irregular in shape and vary greatly in size, but are usually from 1 to 4 inches in diameter. The exudation of gum occurs principally in the spring or in early autumn, after the rainy season, while delimitation and detachment of the bark usually take place during the summer or winter.

As the disease progresses gum exudes on other portions of the bark, which are in turn thrown off. It is quite common for a circle of bark surrounding an old diseased spot to become affected and be thrown off, thus enlarging the spot. The malady gradually spreads in all directions, but principally down on the main crown roots and around the

trunk in a lateral direction (fig. 5). Year after year other portions of bark become affected, until the tree is entirely girdled and thereby killed. In malignant cases the disease runs its course and kills the tree in two years or less, while in mild cases the growth of the tree is scarcely affected, and in a few years the wounds are often completely covered with the new growth from the sides. The destruction of the bark on the trunk does not usually extend over 1 or 1½ feet above the ground, but occurs on the roots for some distance below the surface.

Trees affected with foot rot appear at first as if they were suffering from lack of nourishment. The foliage becomes light yellow and scanty, the leaves developed being smaller than usual; the tree bears considerable fruit, apparently of normal size and good quality. This abundant fruiting is in marked contrast with blight, where a profuse bloom

FIG. 5.—Base of an old orange tree showing injuries and scars produced by foot rot.

is formed, but very little fruit set. In trees suffering from this disease the small limbs die first, but as the malady progresses large limbs succumb, thus giving the tree a ragged appearance. Again, in marked contrast with blight and with severe cases of die-back, no water sprouts develop from the interior of the tree top or from the trunk. In Florida trees are not usually attacked until they are quite old and have been bearing fruit for a number of years. In other regions, however, young trees are said to contract the disease.

Psorosis,[1] a disease known in Florida as "tears" or "gum disease," is often confounded with foot rot, but is unquestionably quite distinct. In appearance it is similar to foot rot, but with it the diseased spots occur on the limbs and occasionally on the trunk, but never on the roots so

[1] From the Greek *ψώρα*, meaning an ulcer.

far as known. Psorosis does not kill the bark entirely, but extends only to the middle layer, the inner bark and cambium layer remaining healthy.

Varieties of trees attacked.—Probably all species of citrous trees may contract mal-di-gomma, but some are very much more subject to it than others. Sweet seedling orange trees (*Citrus aurantium*) are particularly susceptible, and it is in old groves of these that the most damage is done. Sweet orange used as stock for budding is also liable to the disease. This malady is very destructive to the lemon (*C. limonum*), occurring quite commonly on all varieties. Grape fruit (*C. decumana*) is frequently affected, but is much more resistant to attacks than the sweet orange or lemon. Indeed, it is seldom that this fruit is seriously damaged. Tangerine and mandarin oranges (*C. nobilis*) are occasionally affected, but the damage is not usually very great. The sour orange (*C. bigaradia*) is apparently almost wholly free from mal-di-gomma. The writers carried on a careful search for the disease on this species, but succeeded in finding only two unquestionable cases. The sour orange used as a stock for budding remains free from attacks, and in Florida its use for this purpose is almost a sure preventive of the disease. It is probable that the disease occurs on the lime (*C. limetta*) and citron (*C. medica*) also, but no cases have as yet been observed in Florida.

Cause.—Mal-di-gomma has been studied extensively by many investigators, but as yet the cause of the disease is not surely known. It is thought by many to result from the attacks of some parasitic organism, and Professor Briosi[1] describes and names a fungus (*Fusisporium limoni*) which he finds always accompanying the disease. He is inclined to consider the fungus the cause of the trouble, but is in doubt as to whether it is the primary cause. He says, however: "I do not believe there can be any doubt that its presence accelerates the disorganization of the tissues and aids in extending the disease."

The manner in which the disease spreads, appearing at different dates first in one country and then in another, and extending gradually from grove to grove, strongly indicates that it is contagious, being caused or at least greatly aggravated by some parasitic organism. Some investigators also think that the disease is due to physiological derangements, for instance, imperfect aeration of the roots. The most effective treatment known is based largely on this supposition.

Observation has shown that the disease is most common where any of the following conditions exist: Improper drainage; planting the trees so close together that the ground is continually shaded and kept moist; continuous use of organic fertilizers; excessive cultivation; continuous excessive irrigation, which keeps the soil water-soaked; and deep planting.

Trees badly affected with the disease frequently recover if transplanted to some other location, on apparently similar soil, and given

[1] Briosi, loc. cit., 495.

plenty of room. A remarkable instance of this was seen by the writers in a case where 40 acres were planted out some five years ago with large trees affected with foot rot. After three years every tree of the several thousand transplanted to this grove seemed to have fully recovered.

Treatment.—Very many attempts have been made, both in Europe and in the United States, to find remedies for this malady. One of the most important discoveries is that it can be prevented by using immune or resistant stocks. It was early noticed that the sour orange and trees on sour orange stocks were almost absolutely exempt from the malady. By using this stock in setting out young groves the disease can be effectually prevented. On high, dry soils, not suited to the sour orange, grape-fruit stock can be used, as it also is quite resistant.

Many curative treatments prove more or less beneficial, and this has led to conflicting claims as to which is the best. In many cases it has been found sufficient to simply dig away the earth and expose the roots. This probably explains why so many different applications made to the roots seem to benefit the tree. The very act of opening the soil and exposing the roots to the air of itself tends to effect a cure. As the disease is probably caused by a parasite, it is important that no wounds be made on healthy roots in removing the soil. It is desirable to cut away all infected bark and wash the scars with some antiseptic solution, such as sulphurous acid, carbolic acid, or sulphur wash. Where trees are closely planted it is usually necessary to remove and transplant a part of them to give light and air free access to the roots and trunk. The use of highly organic nitrogenous fertilizers should be avoided, and also excessive or deep cultivation.

The following is a summary of the treatments recommended for foot rot:

1. Remove the earth from about the roots for 2 or 3 feet from the trunk, being careful not to wound the healthy roots. When the groves are furnished with irrigation plants of the kind commonly used in Florida, which are capable of delivering a stream of water under considerable pressure, the earth should be washed away rather than dug away from the roots. A good way to do this is to first dig a hole some 3 feet in diameter and 2 or 3 feet deep about 6 feet from the tree; then stand on the opposite side of the tree and wash the soil from under the tree, driving it into the hole previously dug. If no hole is dug before washing out is attempted the soil is likely to bank up around the tree and make it difficult to expose the roots sufficiently. In all cases the roots should be left exposed till recovery takes place, except possibly during a portion of the winter when severe freezes are liable to occur.

2. Cut away all diseased spots in the bark of the roots or trunk and cover the wounds with one of the following antiseptic solutions: (1) Sulphurous (not sulphuric) acid, 15 parts to 85 parts of water. This may be sprayed on the roots. (2) Carbolic acid, 1 part of crude acid to 1

part of water. When diluted 1 to 5 this may be sprayed over the roots. (3) Sulphur wash made by putting 30 pounds of flowers of sulphur in an iron or wooden vessel and mixing enough water (about 12 quarts) with it to make a stiff paste. To this add 20 pounds of finely pulverized 98 per cent caustic soda and stir vigorously. In a few moments the mass becomes hot, turns brown, and then boils up and becomes liquid. As soon as the violent boiling has ceased add enough water to bring up to 20 gallons and strain into a barrel that can be kept tightly corked. For covering cut places use 1 part of this stock preparation to 1 part of water. The roots may be sprayed with 1 part of stock solution to 10 of water.[1] All these solutions should be kept in wooden or glass vessels and should not be allowed to come in contact with metals. It is possible that any of these applications will prove of benefit even if the diseased spots are not cut out. In this latter case, however, care should be taken to saturate the bark of all diseased spots with the solution.

3. When the diseased trees are old and closely set, so that the ground is much shaded, every other tree should be removed and replanted in a new grove.

4. Avoid highly nitrogenous organic fertilizers in diseased groves, using preferably nitrate of soda or sulphate of ammonia as a source of nitrogen.

5. All tools used in infected groves should be cleaned and washed with crude carbolic acid before they are used in healthy groves.

6. In setting new groves dead trees should be replaced with trees budded on sour orange stock.[2]

7. Avoid excessive and deep cultivation in diseased groves. Injuries to the roots, such as are often caused by deep plowing, seem to greatly favor the spread of the disease.

MELANOSE.[3]

Melanose, which in some groves is causing considerable damage, was first brought to the attention of the writers in November, 1892, by Mr. J. A. Barnes, who sent specimens to us from Citra. It apparently attacks all citrous fruits, but develops somewhat more freely on the grape fruit than on the other varieties. It is known to affect the grape fruit, common sweet orange, sour orange, lemon, mandarin, and Satsuma. The disease develops most freely on young, rapidly growing, vigorous shoots. It resembles to some extent the injury produced by the rust mite, and was for a time confounded with this disease. Its

[1] Two quarts of the stock solution to 50 gallons of water makes a very effective remedy for rust mite, and 1 gallon to 50 gallons of water for the six-spotted mite.

[2] Sour stock does better than sweet on low, wet hammock lands, and as well on flatwood land. For high, dry lands grape-fruit stock may be used, since sour stock does not do well and grape fruit is almost exempt from foot rot.

[3] From the Greek *μελας*, black, and *νοσος*, disease.

refusal to yield to the treatment for rust mite, however, led to the discovery that it is distinct from rust.[1]

The disease is undoubtedly of very recent origin or introduction. It has spread rapidly in the region about Citra, and many of the groves there are badly affected. The malady has also been found to occur to some extent at Ocala, Stanton, and Sanford, and is apparently spreading rapidly.

The foliage of trees attacked by this disease is greatly injured, and consequently the general vigor and productiveness of the tree much reduced. The growth of young trees is retarded, and they are apparently permanently stunted if the disease is allowed to continue. The fruit produced is mostly disfigured, some of it so badly as to be unsalable. This is particularly the case with lemons, they, unlike russet oranges, being almost wholly unsalable. At Stanton, where the malady occurs in lemon groves to some extent, from 3 to 4 per cent of the fruit was affected in 1894 and about 2 per cent rendered unsalable. On badly affected grape fruit and orange trees fully 90 per cent of the fruit may be more or less disfigured by melanose. Probably 1 per cent of these are rendered unsalable. The total damage produced by this malady is as yet slight, being about $5,000 annually. It appears to be spreading rapidly, however, and may ere long become one of the most common and most injurious diseases. Great care should be taken to prevent the introduction of this malady into California and other orange-growing countries where it is not yet known to occur.

Symptoms.—The most conspicuous symptom of melanose is the occurrence of small, dark brown spots on the leaves, young stems, and fruits (Pl. VIII). On the leaves and fruits the individual spots, when distinct, are nearly round and are slightly elevated above the surrounding surface. On the stems the spots are usually roundish, but are frequently somewhat elliptical or oblong and elevated, as on the leaves. Only the elevated spot is discolored, the surrounding tissue being of normal color. The spots are at first very minute and yellowish. They gradually increase, however, and swell up, changing to dark brown or nearly black. Many of the spots finally burst near the center and show a small, irregular fissure. Very commonly the under side of the leaves show minute depressions, corresponding to the spots located on the upper surface. On young, partially grown leaves this latter character is usually very evident, each brown spot occurring on a slight elevation of the leaf. The spots vary considerably in size, ranging usually from $\frac{1}{4}$ to 1 mm. ($\frac{1}{100}$ to $\frac{1}{25}$ inch) in diameter. On the common sweet orange and sour orange they range in size from $\frac{1}{4}$ to $\frac{1}{2}$ mm. ($\frac{1}{100}$ to $\frac{1}{50}$ inch). On the grape fruit they are from $\frac{1}{2}$ to 1 mm. ($\frac{1}{50}$ to $\frac{1}{25}$ inch) in diameter, the individual spots being usually much larger and more conspicuous than on common orange or sour orange. On the common orange 388

[1] A brown discoloration of the fruit, caused by the attacks of a surface-feeding mite, *Phytoptus*.

spots were counted on a square centimeter of a badly infected leaf and 44 spots on a square centimeter of one slightly infected. In the grape fruit only 130 spots to the square centimeter were found on a badly infected leaf; these were partly confluent, forming an almost continuous blotch. Where the spots are very abundant they frequently run together, forming large, irregular, dark brown blotches. This frequently occurs on all species of citrous trees affected with the disease, and is found on stems, leaves, and fruits. On the fruits in particular this is of frequent occurrence. As the fruit ripens, the blotches, which are hard and brittle, sometimes become considerably checkered and fissured, similar to the cracking of mud in drying.

FIG. 6.—Melanose on sweet orange twigs. 1, healthy; 2, diseased.

The spots are to some extent formed on both surfaces of the leaf, but are much more abundant on the upper surface. This character is more particularly noticeable in the grape fruit than in other species of citrus. On grape fruit the spots are almost wholly limited to the upper surface. In the common sweet orange and sour orange they occur abundantly on the lower surface, but are still more numerous on the upper surface. On the different portions of the fruit and young stems the spots are apparently uniformly abundant. This malady is most severe on the lower portions of the tree, but the characteristic spots are also found on the leaves and twigs in the tops of large trees, nearly 30 feet from the ground.

The infection, it appears, usually takes place at an early stage in the development of the leaves and stems, and if the disease becomes severe the affected organs are considerably modified in appearance. The leaves become greatly distorted and wrinkled and remain much smaller and more pointed than normally. Many of the leaves fall before reaching maturity, only a scanty foliage remaining on badly affected branches. The branches are also considerably contorted and stunted in severe attacks (fig. 6).

Cause.—From studies that have been made of this disease it seems very probable that it is caused by some vegetable parasite, although the microscopic studies which have thus far been carried on have failed to reveal the presence of any such organism. The disease is apparently contagious, spreading from definite centers. In some groves infected areas are plainly seen. In the centers of these areas, where the disease first started, the trees will be found to be very badly affected, but toward the margins the malady gradually becomes less apparent.

Melanose appears to be of an entirely local nature. In its growth and development each spot is entirely independent of any other spot, probably being caused by a separate infection. The tissue between the diseased spots is evidently perfectly healthy outside of the general debility which results from the infection of such a large portion of the leaf. The strict localization of the disease, so similar to what occurs in scab, again strongly suggests that the disease is caused by some vegetable parasite. Infection can take place apparently only when the tissues are quite young. If the leaves and stems escape the disease until they are nearly full grown the danger of infection is past. This is the case also with fruits, and therefore spraying to prevent the disease must be done early, while the fruits are small. After they reach an inch in diameter they appear to be safe from infection and spraying may then be discontinued.

Preventive measures.—In the summer of 1894 experiments with various fungicides were carried on at Stanton and Citra, with a view to find a preventive of the disease. The copper fungicides, i. e., Bordeaux mixture and ammoniacal solution of copper carbonate, were found to almost wholly prevent the disease if properly applied. In two plats of lemon trees at Stanton, sprayed with Bordeaux mixtures (6 pounds of copper sulphate and 3½ pounds of lime to 50 gallons of water), melanose was absolutely prevented, the most careful search failing to disclose a single fruit showing the characteristic spots. The sprayings were made once a week and twice a week, respectively, for a term of ten weeks, beginning February 3. On an orange tree sprayed at the same time with the lemons the treatment was equally effective. However, both the lemon trees and orange trees were somewhat injured by the Bordeaux mixture, probably largely because of the numerous sprayings given. On adjoining unsprayed lemon trees from 2 to 4 per cent of the fruits and a larger per cent of the foliage were considerably

spotted with the disease. Perhaps half the spotted fruits were so badly disfigured as to be unsalable. In a plat of lemon trees sprayed weekly with ammoniacal solution of copper carbonate (5 ounces to 50 gallons), beginning February 24 and continuing eight consecutive weeks, no melanose could be found on any of the sprayed trees. However, very little developed on the unsprayed trees adjoining this plat.

In another series of experiments at Citra, several plats of very badly infected orange trees were sprayed with Bordeaux mixture (6 pounds of copper sulphate and 3½ pounds of lime to 80 gallons of water). In one of these plats sprayed twice, April 19 (shortly after flowering) and May 16, melanose was almost wholly prevented. Only two slightly spotted fruits were found on the entire plat of twenty-five large trees. Certainly not one-tenth of 1 per cent of the fruit showed even a trace of the disease. On the adjoining unsprayed trees fully 90 per cent of the fruit was diseased, some 50 per cent of it being very badly disfigured. In these experiments the trees also were injured to some extent, probably largely because of the abundance of scale insects on sprayed trees. As melanose was absolutely prevented by Bordeaux mixture of the strength above, it is highly probable that weaker sprays would be equally effective. It is likely that more sprayings will be necessary in treating melanose on the lemon than on the orange because of the more extended flowering period of the former. Although the experiments were mostly with Bordeaux mixture, which has proved fully effective in preventing the malady, it is very likely that ammoniacal solution of copper carbonate will be the most practical remedy, because it is not so apt to injure the trees and will probably prove as effective as Bordeaux mixture.

The following is a summary of practical directions for keeping melanose in check: In treating the lemon for melanose, spray with Bordeaux mixture[1] or ammoniacal solution of copper carbonate.[2] Spray first about a month after the beginning of the spring blooming, or

[1] Take 6 pounds of copper sulphate and 3 pounds of good lime to 80 gallons of water. Slack the lime carefully and dissolve the copper sulphate; then dilute each constituent with water to 25 gallons and mix. Add 6 pounds of soap, dissolved in as many gallons of hot water, and finally add enough water to bring the mixture up to 80 gallons. A resin soap suitable for adding to fungicides can be prepared very easily as follows: Take 40 pounds resin, 20 pounds sal soda (crystalline), and water to make 25 gallons. Place the resin and sal soda in a comparatively large kettle with 5 quarts of water. Boil, meanwhile stirring briskly, until the resin and sal soda are thoroughly melted together and form a frothy mixture without lumps. Now add 20 gallons of cold water, pouring it in rather slowly and with short intervals between, to avoid chilling the mixture too suddenly. When all of the water is added, bring to a boil; then pour out the hot solution, straining through a coarse cloth, and add sufficient water to make 25 gallons of the solution. This, if correctly made, forms a thick, dark-brown, translucent, sirupy solution, which may be preserved as a stock preparation. About 2 pounds of soap are contained to the gallon, and the cost is only about 1½ to 2½ cents per gallon, while ordinary good hard soap costs five to twelve times as much.

[2] See directions for making on p. 24.

when the oldest of the young fruits are about the size of an olive. Spray again about a month after the first application, after flowering has ceased and the youngest fruits are the size of a pea. A third spraying may be made a month later if it is found necessary, but two sprayings will probably be sufficient.

In treating the orange and grape fruit for this disease, use Bordeaux mixture or ammoniacal solution of copper carbonate, prepared as indicated above. Two sprayings should be made, the first about two weeks after the flowers have fallen and the second about a month later. A Vermorel nozzle and a pump giving a good spray should be used. The spray must be applied to the fruits in the form of a fine mist, covering them thinly and evenly. In this way the leaves will be sufficiently coated without any special effort being made to wet them.

SUMMARY.

1. *Blight* attacks trees only when over 5 years old and which are in bearing. It is first manifested by a sudden wilting of the leaves, which soon becomes so bad as to continue even in wet weather. At the beginning of the rainy season following the wilting, vigorously growing sprouts start from the trunk and larger branches. These often continue growing several years, but finally sicken and gradually decline. The spring following the wilting of the top, the branches, which have now become nearly leafless, bloom profusely. These flowers continue to appear for two or three weeks after normal blooming is over. They are small, however, and almost never set fruit. Very little fruit is produced by blighted trees. After flowering the branches usually die, often leaving only the sprouts from the trunk alive and growing. The whole top may be attacked at once or only a single branch, but in any case the entire top ultimately becomes blighted (Pl. II). The affected trees usually linger for many years and rarely die outright, though they may be finally reduced to mere stumps. The roots, for the first year at least, seem perfectly normal. The annual loss from this disease in Florida is about $150,000. The cause is unknown, but it is probably a contagious malady, and, so far as known, is incurable. Affected trees should be dug up and burned as soon as they show the disease and healthy ones set out in their places.

2. *Die-back* or *exanthema* is apparently caused by malnutrition, accompanied by improper drainage, improper cultivation, etc. The disease may be recognized by the very large, dark, pointed leaves, and the reddish-brown stains on certain of the new-growth twigs, which later die back for a considerable distance (fig. 2, *a*). Brown eruptions (Pl. III, fig. 3) occur very abundantly on young and old twigs, all of which finally die back. Swellings produced by gum pockets in the wood occur very abundantly on the young twigs (fig. 2, *b*). Multiple buds form in the axils of the leaves (fig. 2, *c* and *d*). Diseased trees bear little fruit, and that formed soon assumes a pale green color, then a

light lemon yellow, becoming colored prematurely (Pl. III, figs. 1 and 2). The fruits are very commonly more or less disfigured by the characteristic reddish-brown stain. A very large percentage split open and drop before ripening (fig. 4). The loss from this malady is about $100,000 annually in Florida. Withholding all organic nitrogenous manures, ceasing to cultivate, and mulching the soil have been found beneficial treatments. In cases where the disease has been produced by wet soils good drainage will frequently be found an effective remedy.

3. *Scab* or *verrucosis* attacks principally sour oranges and lemons, the common sweet orange being exempt. It occurs in the United States, Australia, and Japan, from which latter country it was probably introduced into America. It causes small excrescences to appear on the young leaves and fruits (Pls. V, VI). These excrescences are at first of a pale, watery green color, but soon become coated with a dusky fungous growth composed of a species of *Cladosporium* (the parasite which causes the disease). The tissues of the warts infested by the fungus are cut off from those below by a formation of cork, which ultimately becomes so abundant as to give the excrescence a gray color. The full-grown warts are $\frac{1}{25}$ to $\frac{1}{4}$ of an inch in diameter and are often confluent. When attacked while still very young, the leaves and fruits are greatly distorted by the disease. In the fruit, especially, the warts cause the tissues below to grow too fast and to form large bumps. These, with the gray excrescences, so disfigure the fruit as to render it nearly valueless. The fungous parasite causing scab is able to spread and infect new spots only during moist weather. For this reason very dry regions are nearly exempt from the malady. The loss from this disease results principally from its action in disfiguring lemons. It does most harm in Florida, where it causes an annual loss of not far from $50,000. The disease can be prevented on lemons by spraying the young fruits from three to five times with ammoniacal solution of copper carbonate.

4. *Sooty mold* is a black fungus, which follows the attacks of certain honeydew-secreting insects. It may be recognized by the sooty black membrane which it forms principally over the upper surfaces of the leaves, fruits, and stems (Pl. VII, fig. 1). The disease greatly reduces the productivity of the trees, and the oranges formed are so badly disfigured by the covering of sooty mold as to be rendered unsalable. The annual loss in Florida is not far from $50,000. Thorough spraying with resin wash has been found very effective. Between December and March of each year three sprayings should be made. Fumigation with hydrocyanic acid gas has also been found an effective remedy. The applications should be made during the winter. A parasitic fungus (*Aschersonia tahitensis*, Pl. VII, fig. 2) has been found which promises to be a very great aid in combating this malady.

5. *Foot rot* or *mal-di-gomma* is the most widespread of all orange diseases. The total damage which it causes is greater than that resulting

from any other one malady, in Florida alone amounting to nearly $100,000 annually. It may be recognized by the exudation of gum from definite patches on the tree near the base. A separative layer is formed by the tree delimiting the diseased bark; the edges of the bark thus freed curve up away from the tree, dry out, and finally fall off (fig. 5). These patches are enlarged by the disease spreading to the adjoining bark. Other patches also form on fresh bark. The malady spreads down the roots and laterally around the trunk. It extends through the bark and cambium layer into the wood, killing all the tissue as far as it extends. In many cases the tree is finally girdled, which of course results in its death. The accompanying or premonitory symptoms are, sparse foliage, small yellow leaves, and the dying of small limbs over the tree. The disease is apparently contagious, probably being caused by some minute parasitic organism. It is also thought that improper aeration of the roots induces the disease. Sweet seedling orange trees and lemons are particularly subject to the malady, while grape fruit is but slightly subject to it, and sour orange is almost wholly exempt. The malady may be prevented by using sour orange stocks on lowlands and flatwoods, and grape-fruit stocks on high and dry pine lands. Removing the soil from around the crown roots is the most effective treatment. This can be best done by using a stream of water under considerable pressure. This washes the soil away without injuring the roots. Cutting away the diseased portions of bark and wood and washing or painting the wounds with a solution of sulphurous acid, carbolic acid, or sulphur wash is recommended as beneficial. Avoid the excessive use of nitrogenous organic manures, excessive cultivation, and immoderate irrigation. Give good drainage in all cases, and if the trees are planted too thick, so that the ground is shaded, thin them out.

6. *Melanose*, which attacks all citrous fruits, is a new disease. It is as yet known only from a few points in Florida and does not cause much damage, probably only about $5,000 in 1894. However, it seems to be spreading, and is capable of causing great losses should it become widely distributed. It forms minute brown spots on the leaves, twigs, and fruits (Pl. VIII). These brown spots appear when the fruit and leaves are still young, and do not form on old tissue. They reach a size of from $\frac{1}{100}$ to $\frac{1}{25}$ of an inch in diameter and are often very numerous, sometimes running together over large areas, greatly staining and disfiguring the fruit. In bad cases the trees are much injured by the malady, but ordinarily most of the damage results from the discoloring of the fruit. Lemons particularly are unsalable if attacked by melanose to any considerable extent. The cause of this disease is not certainly known, but it is very probably some minute vegetable parasite. Bordeaux mixture or ammoniacal solution of copper carbonate are very effective remedies if applied two or three times to the young fruits.

EXPLANATION OF PLATES.

Plate I. *Healthy sweet orange tree.*—A budded tree about 15 to 18 years old, growing on very sandy hammock, on shores of Lake Eustis, Fla. Photographed by H. J. Webber and W. T. Swingle, summer of 1894.

Plate II. *Blighted orange grove.*—An exceptionally badly affected grove on shores of Little Lake Harris, Fla. On sandy hammock land. Twenty trees in succession in the row shown were blighted. The nearest trees show the growth of water shoots from the trunk and lower branches. All have been blighted from one to three years. Photographed by W. T. Swingle, summer of 1892.

Plate III. *Die-back or exanthema.*—Fig. 1, an orange, two-thirds grown, affected with die-back, showing the characteristic sickly lemon-yellow color, the cracked apex, and reddish-brown stain. Fig. 2, mature die-back orange, showing the reddish-brown stains. Fig. 3, 2-year-old orange twig, showing the eruptions which almost invariably accompany die-back. Fig. 1 painted by Müller; figs. 2 and 3 painted by Miss D. G. Passmore. Natural size.

Plate IV. *Die-back or exanthema.*—A tree of sweet orange (*Citrus aurantium*) badly affected with die-back. The outer branches have died back and the new growth shows the characteristic large leaves. From a photograph by H. J. Webber, taken at Fort Mason, Fla., April, 1894.

Plate V. *Verrucosis or scab of lemon.*—Shows leaves and one-third grown fruits distorted by the characteristic bumps and warts. Painted by Miss D. G. Passmore. Natural size.

Plate VI. *Verrucosis on sour orange and lemon.*—Figs. 1–4, sour orange.—fig. 1, old leaf, seen from above; fig. 2, old, distorted leaf, seen from below; fig. 3, very young fruit, showing warts on calix as well as on fruit and pedicel; fig. 4, one-fourth grown fruit, showing bumps and warts. Figs. 5–10, lemon.—fig. 5, one-third grown lemon slightly affected; fig. 6, one-fourth grown fruit, showing prominent bumps and warts; figs. 7 and 8, young lemons, showing bumps and warts; fig. 9, young healthy lemon; fig. 10, one-half grown lemon, slightly distorted. Photographed by W. T. Swingle April, 1894. About six-sevenths natural size.

Plate VII. *Sooty mold of the orange following the mealy wing* (*Aleyrodes citri*).—Fig. 1, the sooty mold shows as a black covering on the fruit and upper surfaces of the old leaves. The larval scales of the mealy wing are shown on the lower surfaces of the leaves. Fig. 2, an orange leaf, showing the lower surface covered with the numerous pustules of *Aschersonia tahitensis*, growing parasitically on the larvæ of the mealy wing. Painted by Miss D. G. Passmore from material from Gainesville, Fla., February 20, 1894. Both figures natural size.

Plate VIII. *Melanose on grape fruit.*—Shows characteristic specks on leaves and twigs. Specimens from Citra, Fla. Photographed October, 1894, by W. T. Swingle and H. J. Webber. Two-thirds natural size.

HEALTHY SWEET ORANGE TREE.

BLIGHTED ORANGE GROVE.

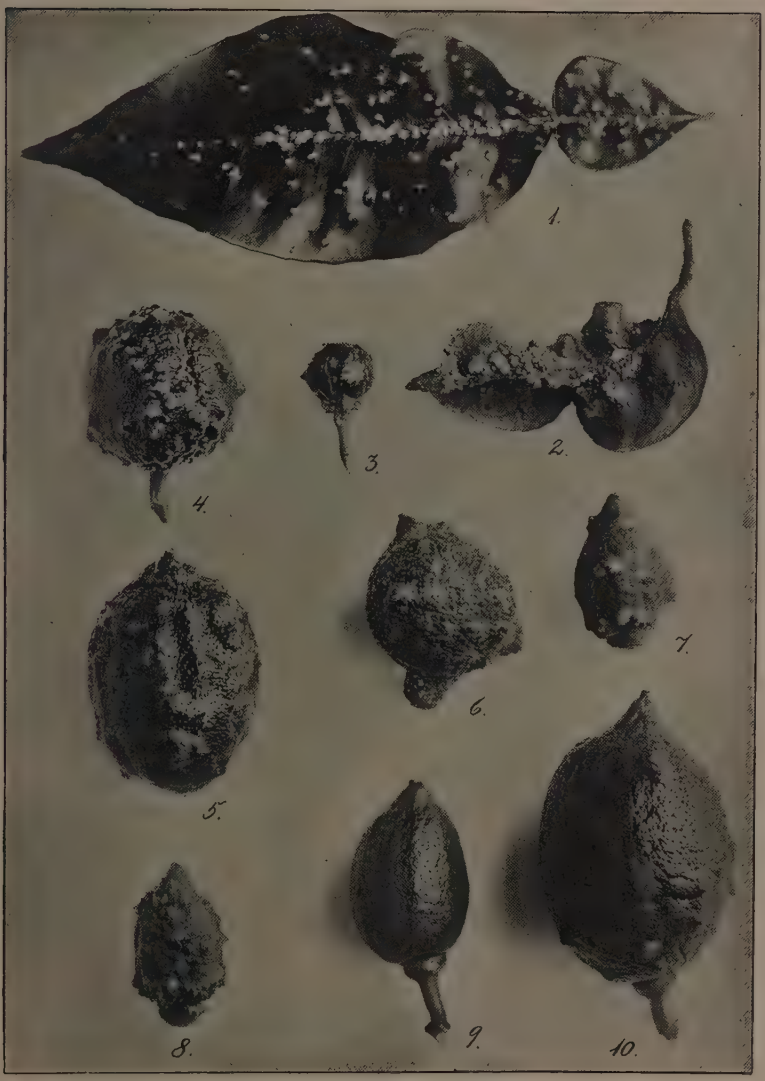
DIE-BACK OR EXANTHEMA OF ORANGE.

Forbes Co. Boston. D. G. Passmore.

DIE-BACK OR EXANTHEMA OF ORANGE.

Forbes Co. Boston. D. G. Passmore.

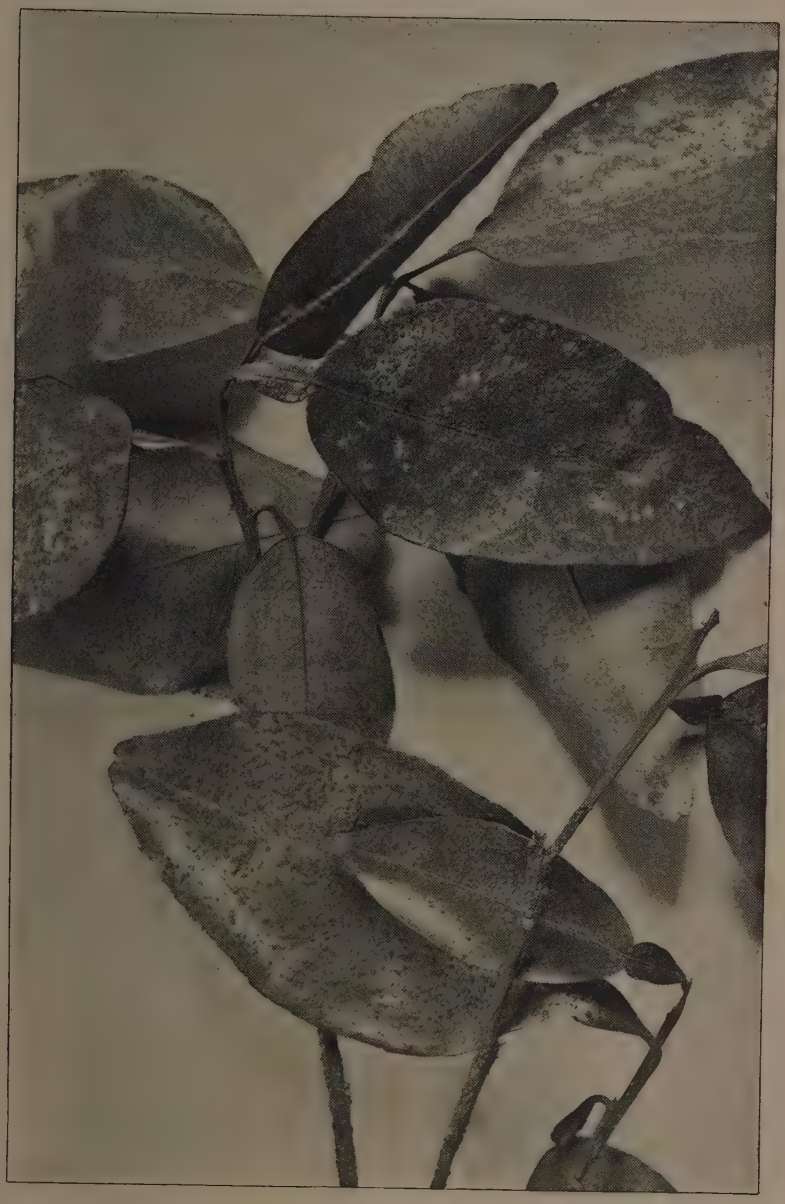
VERRUCOSIS OR SCAB OF LEMON.



VERRUCOSIS OF SOUR ORANGE AND LEMON.

Forbes Co. Boston. D. G. Passmore.

SOOTY MOLD OF THE ORANGE, FOLLOWING THE MEALY WING OR WHITE FLY (ALEYRODES CITRI).



MELANOSE ON GRAPE-FRUIT.